Reproductive competency of male and female neotenics of *Reticulitermes flavipes* (Isoptera: Rhinotermitidae)

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ABSTRACT

Numerous male and female neotenic reproductives were observed in colonies of *Reticulitermes flavipes*. Three colonies had almost equal numbers of female and male neotenics (37:35, 4:2, 10:3) and one colony was significantly female skewed (10:2). Spermatozoa were present in all male and female neotenics, indicating that all were reproductively competent. Female ergatoid and nymphoid neotenics showed no significant difference in spermatheca size and terminal oocyte size, which ranged from <200 um to >800 um diameter. In immature termites, which served as controls for each colony, no spermatozoa were observed in the spermatheca. The testes and spermatheca of immatures were much smaller than that of neotenics. Female swarmers were found to lack spermatozoa in the spermatheca, which confirms published literature that insemination of alates does not occur in the natal nest.

INTRODUCTION

Many termite colonies survive the loss of the founding pair, the queen and king, by producing replacement reproductives, which are called neotenics. These new reproductives develop from immature stages, such as workers and nymphs. Those that develop from workers are termed ergatoid neotenics (Fig. 1), whereas those that develop from nymphs are termed nymphoid neotenics (Fig. 2).

Fig. 1. An ergatoid neotenic. The thorax (circle) lacks wing buds.

Fig. 2. A nymphoid neotenic with arrows pointing to developing wing buds.

Neotenics have been documented in 199 termite species (Myles 1999). Unlike the primary leading colonies, hundreds of neotenics have been observed in *R. flavipes* colonies (Howard & Haverty 1980). It has been speculated that neotenics may function as a vital factor in colony expansion (Grace 1996). However, the numbers of neotenics that are actually reproducing in a termite colony has yet to be investigated.

Research Objectives:

- **To determine the reproductive status of female and male neotenics in laboratory colonies.**
- **To determine the reproductive status of swarming female alates.**

MATERIALS AND METHODS

A total of four laboratory colonies were dismantled, and the numbers of each caste were counted. The colony size, caste composition, and sex ratio were recorded.

Histological procedures were used to examine the reproductive organs of male and female neotenic reproductives and immatures, including workers and/or nymphs, which served as controls.Measurements of reproductive organs were made for each sex.

Female (Fig. 3 and 4)	Male (Fig.6 and 7)
Largest terminal oocyte	Largest testicular lobe
Presence/absence of spermatozoa (Fig. 5) in spermatheca	Presence/absence of spermatozoa in testes
Diameter of recurved tip of spermatheca	

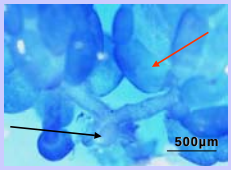

Fig. 3. The reproductive system of a female neoteniceshowing the sperm storage organ, the spermatheca (→), and the paired ovaries containing large terminal oocytes (→).

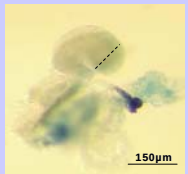

Fig. 4. Diameter of the recurved tip of the spermatheca of a female neotenic.

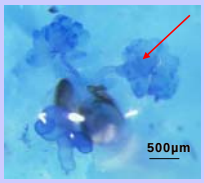

Fig. 6. The reproductive system of a king showing the paired testes (→) comprised of many lobes.

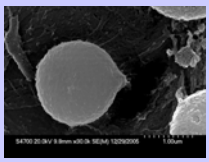

Fig. 5. SEM picture of a *R. flavipes* spermatozoön, which is aflagellate, spherical, and about 2 um diameter.

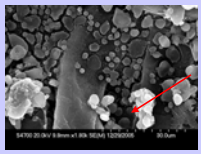

Fig. 7. Spermatozoa (→) in the testis of a male neotenic.

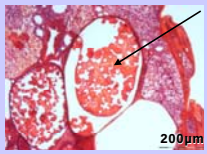

Fig. 8. The largest terminal oocyte (→) of a female nymphoid neotenic.

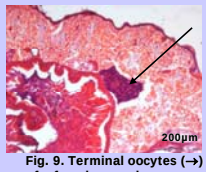

Fig. 9. Terminal oocytes (→) of a female nymph.

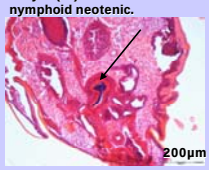

Fig. 10. Sperm within spermatheca (→) of a female nymphoid neotenic.

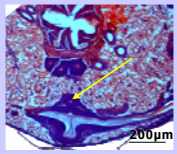

Fig. 11. Rudimentary spermatheca (→) of a female nymph.

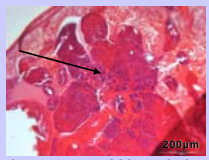

Fig. 12. Sperm within testicular lobes (→) of a male nymphoid neotenic.

Fig. 13. Sperm (→) within testicular lobes of a male nymph.

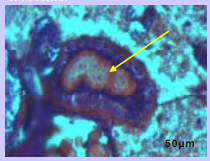

Fig. 14. spermatheca (→) of a female alate.

RESULTS & DISCUSSION

- **All female and male neotenics were reproductively competent**
  - Spermatozoa present in the spermatheca (Fig.10)
  - Large terminal oocytes (variable size)(Fig.8)
  - Spermatozoa present in the basal testes (Fig.12)
- **All female nymphs were not reproductively competent**
  - Spermatozoa absent in the spermatheca (Fig.11)
  - Rudimentary terminal oocytes and spermatheca (Fig.11)
- **All male nymphs were potentially reproductively competent**
  - Spermatozoa present in the testes (Fig.13)
- **No spermatozoa were observed in the spermatheca of alates, which is consistent with the results of Dean & Gold (2004)**
- **A mucus-like substance in the lumen of the spermatheca was observed in alates**
  - First time reported in termites (Fig. 14)
  - May serve as a sperm energy source as has been documented in other insects (Schoeters & Billen 2000)

Table 1. Sex ratio (female:male) of various castes/development stages in *R. flavipes* laboratory colonies

Colony	Workers (N≥ 50)	Nymphs (N ≥ 50)	Soldiers (N>10)	Neotenics	
				Ergatoid	Nymphoid
A12	31: 24 χ^2 = 0.9	0: 50 χ^2 = 50.0**	6: 9 χ^2 = 0.6	3: 0 χ^2 = 3.0	1: 2 χ^2 = 0.3
A31	28: 26 χ^2 = 0.1	50: 0 χ^2 = 50.0**	0: 14 χ^2 = 14.0**	10: 2 χ^2 = 5.3*	n.a.
F1	25: 39 χ^2 = 3.1	30: 40 χ^2 = 1.43	28: 20 χ^2 = 1.3	12: 10 χ^2 = 0.2	25: 25 χ^2 = 0.0
A45	9: 41 χ^2 = 20.5**	41: 9 χ^2 = 20.5**	4: 18 χ^2 = 8.9**	6: 2 χ^2 = 2	4: 1 χ^2 = 1.8

Chi-square are tested, 1 d.f. *=P<0.05, **=P<0.01

CONCLUSIONS

Numerous neotenic reproductives occur in *R. flavipes* colonies

All neotenics are reproductively competent

Neotenic reproductives play a vital role in colony expansion

REFERENCES

Dean, S. R., and R. E. Gold. 2004. Sex ratio and development of the reproductive system in castes of *Reticulitermes flavipes* (Kollar) (Isoptera: Rhinotermitidae). *Ann. Entomol. Soc. Am.* 97: 147-152.

Grace, J. K. 1996. Temporal and spatial variation in caste proportions in a northern *Reticulitermes flavipes* colony (Isoptera: Rhinotermitidae). *Sociobiology* 28: 225-231.

Howard, R. W., and M. I. Haverty. 1980. Reproductives in mature colonies of *Reticulitermes flavipes*: abundance, sex-ratio, and association with soldiers. *Environ. Entomol.* 9: 458-460.

Myles, T. G. 1999. Review of secondary reproduction in termites (Insecta: Isoptera) with comments on its role in termite ecology and social evolution. *Sociobiology* 33: 1–94.

Schoeters, E., and J. Billen. 2000. The importance of the spermathecal duct in bumblebees. *J. Insect Physiol.* 46: 1303-1312.

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